Nitrate fertilization increases *kiwifruit plant* tolerance to *Pseudomonas syringae* pv. *actinidiae*

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Introduction

Pseudomonas syringae pv. *actinidiae* (Psa) is the pathogen responsible for the kiwifruit bacterial canker (KBC), for which no curative methods have been developed yet. The source of nitrogen (N) may have consequences on overall plant nutritional status, which in turn may also affect the plant's predisposition for pathogen infection. However, the lack of knowledge on how kiwifruit plants (*Actinidia* spp.) respond to infection by Psa when grown under different N supplies hinders the possibilities to use N supply in integrated approaches to diminish disease severity. The aim of this study was to understand how nitrate (NO_3^-) and ammonia (NH_4^+) modulate plant defence mechanisms against Psa, paving the way for the development of novel N fertilization regimens that increase plant resilience to the pathogen, or that ensure plant growth and productivity even with Psa infection.

Methods

1. *A. chinensis* var. *deliciosa* cv. 'Hayward' where grown for 21 days in a hydroponics system with nutritive solutions differing in the type of N supply: 214 µM NO_3^-, 214 µM NH_4^+ or a mixture of both (Mix - 107 µM NO_3^- + 107 µM ppm NH_4^+).
2. Psa was inoculated onto plant leaves by rubbing the abaxial surface with an infected swab.
3. Fourteen days post inoculation (dpi) plants were sampled for the analysis of: photosynthetic capacity, Psa endophytic population, total N, mineral composition and gene expression.

Results and Discussion

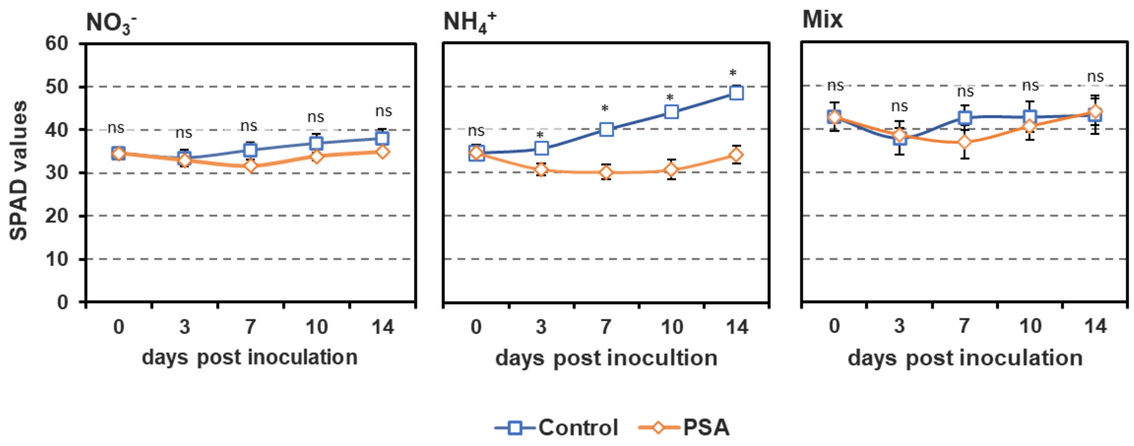

Fig. 1 – Photosynthetic capacity measured as SPAD values.

Photosynthetic capacity of plants under **NH_4^+** supply decreased along the experimental trial.

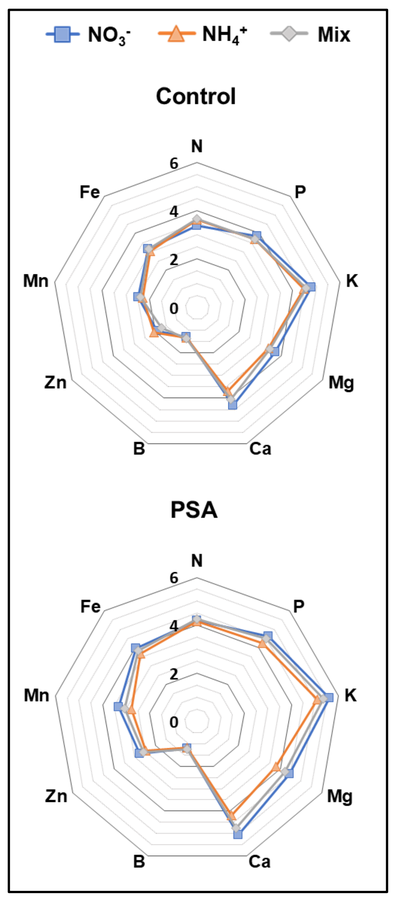

Fig. 3 – Mineral accumulation in plant tissues (mg in log values) .

Supplementation with **NO_3^-** led to **lower Psa endophytic** population in plant tissues, whereas NH_4^+ and Mix led to higher infection rate.

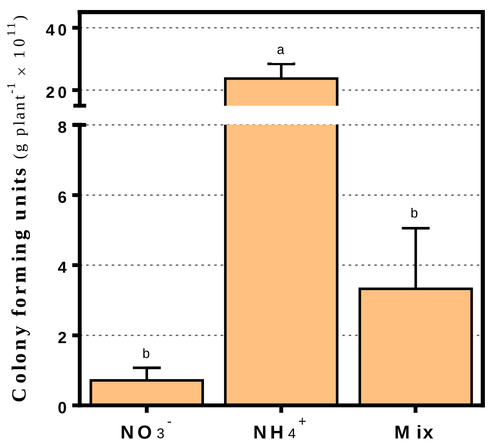

Fig. 2 – Density of Psa population in plant tissues.

Total N was higher in plants grown under **NH_4^+ and Mix** supply. On the other hand, **NO_3^-** led to higher concentrations of **P, K, Mg, Ca and Mn**, suggesting that it has an overall positive effect on mineral nutrition in kiwifruit plants.

NH_4^+ induced the expression of genes related to **plant stress** (*PR1*) and **secondary metabolism** (*LOX*, *PAL* and *SAM*). Genes related with **N metabolism** were differently regulated **depending on the N source**: whereas *GLU1* and *GDH1* were overexpressed with NH_4^+ and Mix, NO_3^- led to overexpression of *GAD1*.

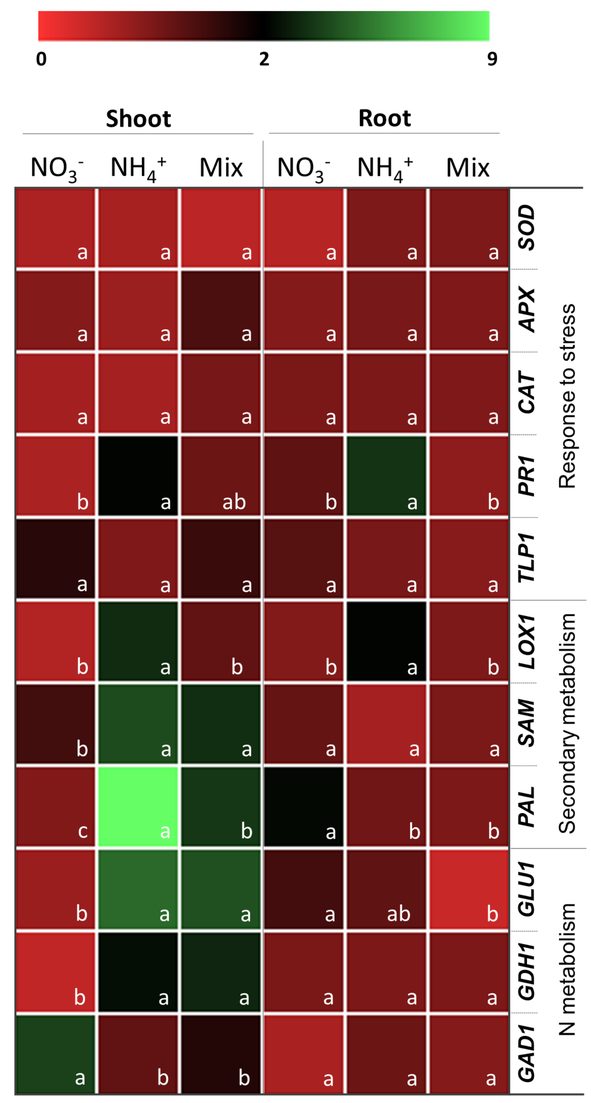

Fig. 4 – Relative fold of expression of genes *SOD* (superoxide dismutase), *APX* (ascorbate peroxidase), *CAT* (catalase), *PR1* (pathogenesis-related protein 1), *TLP1* (thaumatin-like protein 1), *LOX1* (lipoxygenase 1), *PAL* (phenylalanine ammonia lyase), *SAMs* (s-adenosylmethionine synthetase 1), *GLU1* (glutamate synthase 1) and *GDH1* (glutamate dehydrogenase) and *GAD1* (glutamate decarboxylase). Within each structure (shoot or root), different letters represent statistically different means at $p < 0.05$. In red: no alteration or downregulation of gene expression; in black/green: upregulation of gene expression.

Conclusions

- ✓ NO_3^- led to lower Psa colonization and maintenance of plant photosynthetic capacity, having potential to be included in integrated pest management strategies against Psa.
- ✓ NO_3^- could have increased plant tolerance to the pathogen by improving P, K, Mg, Ca and Mn nutrition.
- ✓ The higher levels of total N in NH_4^+ and Mix-supplied plants may have underpinned the increased Psa colonization observed with these treatments.

Acknowledgments

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